Marine Sensor/Autonomous Underwater Vehicle Integration Project

Dr. Thomas L. Hopkins
Department of Marine Science
University of South Florida
St. Petersburg, FL 33701-5016
phone: (727) 553-1501 fax: (727) 553-3967 email: thopkins@marine.usf.edu
Award#: N000149710504

LONG-TERM GOALS

The long-term goal is continued support of research that will integrate a number of advanced oceanographic sensors into autonomous underwater vehicles (AUVs). Support of individual sensor projects at USF takes the form of: 1) enhancements to existing facilities; 2) sensor/vehicle integration; 3) calibration expenses to keep equipment at the necessary standards and ensure integrity of resultant data; 4) support of AUV operations; 5) experimentation and testing of methodologies and equipment; and; 6) engineering/consultation.

OBJECTIVES

This project provides the necessary resources for the Center for Ocean Technology (COT) to support the technical requirements of USF Department of Marine Science's AUV-related sensor projects. The objective is to efficiently design, integrate, test and deploy developed sensors on AUVs. This work is accomplished through use of the Center's varied labs, equipment and human resources.

APPROACH

COT provides comprehensive resources for AUV/sensor integration, testing and deployment. The approach is to provide the faculty and students associated with the sensor development projects with an experienced, suitably trained staff and appropriate equipment resources to effect this mission.

WORK COMPLETED

AUV Sensor Integration

The Dual Light Sheet and Shadowed Image Particle Profiling and Evaluation Recorder (DLS /SIPPER, Hopkins, "Comprehensive Marine Particle Analysis System") were adapted to the FAU OEX AUV in early 1999. Work included new syntactic foam, integration of the SIPPER data logging system and experimental microelectromechanical systems (MEMS) accelerometers to monitor payload motion. The DLS/SIPPER payload was deployed at the ONR-sponsored CoBOP operation at Lee Stocking Island, Bahamas, in late May 1999. COT supported operations included: 1) deployment from the RV Suncoaster; 2) supply and operation of chase boat; 3) retrieval and analysis of data for researchers and; and 4) providing dive support. Deployments were successful, allowing the first ever field test of an AUV-mounted nonintrusive particle measurement system with integral water sample volume measurement capability.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1999		**00-00-1999 to 00-00-1999**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Marine Sensor/Autonomous Underwater Vehicle Integration Project	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of South Florida,Department of Marine Science,140 Seventh Ave. South,St. Petersburg,FL,33701**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT **unclassified**	b ABSTRACT **unclassified**	c THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

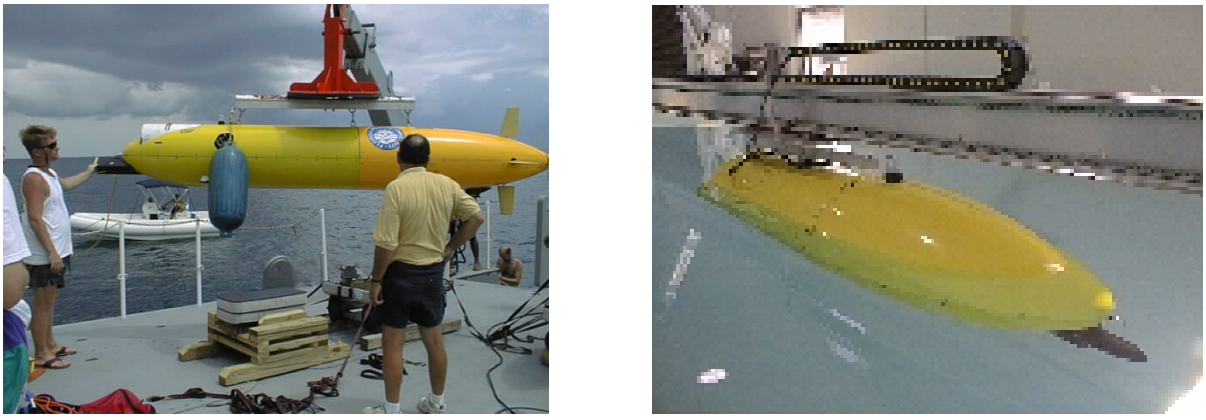
The Real-time Ocean Bottom Topography system (ROBOT, Carder, Costello "Optical Variability and Bottom Classification in Turbid Waters") was deployed under this project in April 1999 and again in May of 1999. This project included deployment support including: 1) payload prep and integration with LONWorks (all software and hardware); 2) chase boat support; 3) dive support; 4) data retrieval and analysis for researchers.

The Bottom Classification and Albedo Package (BCAP, Carder) was integrated into an OEX payload section in early 1999. This project's support included: 1) fabrication of OEX payload shell and mechanical structure; 2) design and fabrication of adjustable mounting system; 3) cutting and forming syntactic foam; 4) installing the drop weight system; 5) performing tests, including trim and balance; 6) deployment at CoBOP 99; 7) retrieving and analyzing data for researchers and; 8) providing chase boat and dive support for field operations. Deployments were successful despite minor electrical problems with the instrument package.

The Spectrophotometric Elemental Analysis System (SEAS, Byrne, "Autonomous *In-Situ* Analysis Of The Upper Ocean: Construction of a Compact, Long Pathlength Absorbance Spectrometer") was deployed at CoBOP in late May 1999 and deployed again at the South Florida Test Facility in July 1999. The support included: 1) deployment from the RV Suncoaster (CoBOP), Oceaneer (South Florida); 2) supply and operation of the chase boat (CoBOP); 3) retrieval and analysis of data for researchers; and; 4) provision of dive support. Deployments were successful and provided the first AUV field test of the SEAS instrument configured for nutrient analysis.

Work has continued on AUV integration of a nutrient sensor (Fanning, "Development of a Remote Sensing Capability for Nitrogen-Bearing Nutrients on an Unmanned Underwater Vehicle in the Coastal Ocean"). Deployment on an AUV occurred in July 1999. Engineering support was provided for deployments.

AUV operations locally (and remotely, in conjunction with FAU) will continue to be supported through the end of the project.



(a) ***(b)***

1. (a) Deployment of the DLS/SIPPER instrument at FAU, June 1999; and (b) the interior of our 9,000-gallon test flume showing ROBOT in an OEX test vehicle.

Sensor/System Test Flume

The Center for Ocean Technology is home to a 9,000-gallon test flume for pre-testing developed sensors before expensive deployment (figure 1(b)). Upgrades to the flume's internal structure were completed over the past year. These include: 1) improvement to the water drainage system and; 2) improvements to the water recirculating system.

Support Equipment

The Center for Ocean Technology provides limited calibration and maintenance capability for the USF Department of Marine Science. Miscellaneous lab equipment to support development efforts has been purchased; however, this equipment is also used to support maintenance of completed sensor systems as well as AUVs. A calibration lab is being set up at this writing and is expected to be complete by the end of the calendar year. Standards for voltage, current, and frequency will be available in the lab.

Training

Training of support personnel was completed including: LONWorks, American Vacuum Society short courses, MCNC/CRONOS MUMPS processes, and microTAS short courses. Several conferences were attended including the MTS IEEE Oceans '99, Oceanology International '99, the 46th ASMS Conference, the National Ocean Conference, Pittcon '99, SPIE's 1999 Symposium, and a Defense Science and Technology conference.

Experimentation and Testing

A rapid and inexpensive system for experimentation and testing of instrument payload sections has been designed and is nearing completion at this writing. The unit, called ROVEX, consists of an OEX tail section configured to accept standard OEX payloads. The unit has remote control capabilities, real-time video, DVL, side-scan sonar capability and built-in remote/autonomous operation capability. The initial test is set for mid December 1999 in the COT test flume.

RESULTS

AUV Sensors and Deployments

*SEAS instrument: Several successful operational tests of both the vehicle and sensor. Tested pH, nitrite and nitrate capabilities.
*Dual Light Sheet/Shadowed Image particle Profiling and Evaluation recorder: Integrated DLS/SIPPER into the FAU OEX AUV in early, 1999, deployed at CoBOP in May 1999, Dania in June 99, and provided first successful field test of the integrated imager and nonintrusive particle velocity measurement system.
*Nutrient Sensor: Supported field operation.
*Bottom Classification Albedo Package: Integrated BCAP into an OEX AUV and supported field operations at CoBOP '99.
*AUV operations: Florida west coast, Florida east coast, Lee Stocking Island.

*The Center's 9,000-gallon test flume has been upgraded and can now provide testing of AUV sensors with sea water and recirculating water flow.

IMPACT/APPLICATIONS

The Center for Ocean Technology continues to build significant expertise in: 1) adapting sensors to AUVs; 2) operating AUVs at sea; 3) building AUV-specific custom hardware; and 4) testing AUVs and related systems. This work covers several aspects of AUV integration, including LONWorks, adaptive sampling, remote control and monitoring, sea sampling, etc. This expertise is available not only for USF AUV-related projects, but to the general oceanographic research community as well.

TRANSITIONS

The continued AUV-related interactions between USF/COT and FAU strengthen arguments for AUV use as a viable oceanographic research tool. The ongoing efforts of this project will help to increase the efficiency of marine research and will aid in transitioning the general technology to other research organizations.

RELATED PROJECTS

1) Byrne, Robert. "Development of an Underwater *In-Situ* Spectrophotometric Sensor for Seawater pH."
2) Byrne, Robert. "Autonomous *In-Situ* Analysis Of The Upper Ocean: Construction of a Compact, Long Pathlength Absorbance Spectrometer"
3) Carder, Kendall and Costello, David. "Optical Variability and Bottom Classification in Turbid Waters."
4) Fanning, Kent. "Development of a Remote Sensing Capability for Nitrogen-Bearing Nutrients on an Unmanned Underwater Vehicle in the Coastal Ocean."
5) Hine, Al. "Sea Floor Acoustic Properties, Test Bed Definition, Geologic Mapping and Sedimentary Processes Using Autonomous Underwater Vehicle (AUV) Technology."
6) Hopkins, Thomas. "Comprehensive Marine Particle Analysis System."